भारतीय मानक
Indian Standard

IS 6518 : 2017
(Reaffirmed 2022)

जलोशयों में तलछट के नियंत्रण की मार्गदर्शिका

(दूसरा पुनरीक्षण)

Guidelines for Control of Sediment in Reservoirs

(Second Revision)

ICS 17.120.20

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुरशाह ज़फर मार्ग, नई दिल्ली–110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI-110002
www.bis.org.in www.standardsbis.in

April 2017 **Price Group 2**

Reservoirs and Lakes Sectional Committee, WRD 10

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Reservoirs and Lakes Sectional Committee had been approved by the Water Resources Division Council.

Sedimentation of reservoirs is a natural phenomenon and is a matter of vital concern for storage projects in meeting the various demands, like irrigation, hydro-electric power, flood control, etc, since it affects the useful capacity of the reservoirs based on which the projects are expected to be productive for a design period. Further the sediment deposition adds to the forces on structures in dams, spillways, etc.

The rate of sedimentation will depend largely on the annual sediment load carried by the stream and the extent to which the same will be retained in the reservoir. This in turn, depends upon a number of factors; such as the area and nature of the catchment, land use pattern (cultivation practices, grazing, logging, construction activities and conservation practices), rainfall pattern, storage capacity, period of storage in relation to the sediment load of the stream, particle size distribution in the suspended sediment, channel hydraulics, location and size of sluices, outlet works, configuration of the reservoir, and the method and purpose of releases through the dam.

Therefore, attention is required to each one of these factors for the efficient control of sedimentation of reservoirs with a view to enhancing their useful life. Because of the limited data available, the recommendations are only of general character.

This standard was first prepared in 1972 and revised in 1992. It is being revised now to update its contents in line with the current experience and practices.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test for analysis, shall be rounded off in accordance with IS 2 : 1960 ‘Rules for rounding off numerical values (*revised*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

GUIDELINES FOR CONTROL OF SEDIMENT IN RESERVOIRS

(Second Revision)

1 SCOPE

1.1 This standard covers the various engineering measures for the control of sediment in reservoirs.

1.2 It does not cover the agronomical and forestry measures in detail for the control of watershed erosion and the situations arising out of landslides, avulsions, etc, in the reservoir.

2 REFERENCES

The following standards contain provisions, which through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below:

IS No.	*Title*
5477	Methods for fixing the capacities of reservoirs
(Part 1) : 1999	General requirements (*first revision*)
(Part 2) : 1994	Dead storage (*first revision*)
(Part 3) : 2003	Live storage (*first revision*)
(Part 4) : 1971	Flood storage
12182 : 1987	Guidelines for determination of effects of sedimentation in planning and performance of reservoirs

3 GENERAL

3.1 Where a reservoir storage capacity is large in comparison to the annual run-off from the catchment area (large capacity inflow ratio), all the waterborne sediment carried by the run-off water may be deposited in the bed of the reservoir. The bed load may generally deposit along the thalweg or pre-reservoir course, but the suspended sediment which takes a long time to settle will spread more evenly all over the reservoir bed. A small amount of sediment deposit in the reservoir may be removed by the water drawn off through sluice outlets, but such action is generally local.

3.1.1 When the run-off of the catchment of reservoir is large in comparison to the reservoir capacity (small capacity inflow ratio), the reservoir discharges the surplus freely for long periods, and it is possible that a considerable proportion of the sediment in suspension may be passed off with the surplus water, but the bed load and a part of suspended sediment will be deposited in the reservoir bed.

3.2 The probable rate of sedimentation in any proposed reservoir may be estimated in the following ways:

a) From the observations of sediment load carried by the streams,
   1) using simulation models; and
   2) using sediment transport,
b) From predictions on the basis of total erosion, its transportability and reservoir trap efficiency; and
c) On the basis of sedimentation in existing reservoirs with similar catchment characteristics, the sedimentation deposits of which have been surveyed over a sufficiently long period.

4 METHODS FOR CONTROLLING THE SEDIMENTATION

4.1 There are several factors involved in controlling sedimentation in reservoirs and they relate to aspects on,

a) design of reservoir;
b) control of sediment inflow; and
c) control by outlet works.

All these aspects are to be simultaneously taken note of and appropriate measures be adopted.

4.2 Design of Reservoirs

The capacity of reservoirs is governed by a number of factors which are covered in IS 5477 (Parts 1 to 4). From the point of view of sediment deposition, the following points may be given due consideration:

a) The sediment yield which depends on the topographical, geological and geomorphological set up, meteorological factors, land use/land cover, intercepting tanks, etc;
b) Sediment delivery characteristics of the channel system;

c) The efficiency of the reservoir as sediment trap;
d) The ratio of capacity of reservoir to the inflow;
e) Configuration of reservoir;
f) Method of operation of reservoir; and
g) Provisions for silt exclusion.

4.2.1 The rate of sediment delivery increases with the quantum of discharge.

4.2.2 The percentage of sediment trapped by a reservoir with a given drainage area increases with the increased capacity. In some cases an increased capacity will however, result in greater loss of water due to evaporation. However, with the progress of sedimentation, there is decrease of storage capacity which in turn lowers the trap efficiency of the reservoir.

4.2.3 The capacity of the reservoir and the size and characteristics of the reservoir and its drainage area are the most important factors governing the annual rate of accumulation of sediment. Periodical reservoir sedimentation surveys provide guidance on the rate of sedimentation. In the absence of observed data for the reservoir concerned, data from other reservoirs of similar capacity and catchment characteristics may be adopted.

4.2.4 Sedimentation takes place not only in the dead storage but also in the live storage space in the reservoir. The practice for design of reservoir is to use the observed suspended sediment data available from key hydrologica1 networks and also the data available from hydrographic surveys of other reservoirs in the same region.

This data may be used to simulate sedimentation status over a period of reservoir life as mentioned in IS 12182.

4.2.5 *Raising the Dam at Periodic Intervals*

Engineering economic analysis of some reservoir projects probably would show that it is cheaper to build a substantially lower dam initially, and to raise it at intervals unti1 its ultimate height for the given original capacity so that long useful life may result. Stage-wise construction also provides lower trapping efficiency and less evaporation in the initial stages.

However, this method may not be feasible in all the existing dams. Wherever this method is contemplated, proper consideration should be given on the strength of the existing foundation for the proposed ultimate height.

4.3 Control of Sediment Inflow

There are many methods for controlling sediment inflows and they can be divided as follows:

a) Watershed management/soil conservation measures to check production and transport of sediment in the catchment area, and
b) Preventive measures to check inflow of sediment into the reservoir.

4.3.1 The soil conservation measures are further sub-divided as:

a) Engineering,
b) Agronomy, and
c) Forestry.

4.3.1.1 The engineering methods include,

a) use of check dams formed by building small barriers or dykes across stream channels.
b) contour bunding and trenching;
c) gully plugging; and
d) bank protection.

NOTE — Check dams are sometimes known as settling basin or sedimentation basin.

4.3.1.2 The agronomic measures include establishment of vegetative screen, contour farming, strip cropping and crop rotation.

4.3.1.3 Forestry measures include forest conservancy, control on grazing, lumbering, operations and forest fires along with management and protection of forest plantations.

4.3.2 Preventive measures to check inflow of sediment into the reservoir include,

a) Restricting the waste/sediment entering into the reservoirs due to agricultural and infrastructural activities surrounding the submergence; and
b) Construction of by-pass channels or conduits.

4.3.3 *Check Dams*

a) They help to arrest degradation of stream bed thereby arresting the slope failure; and
b) They reduce the velocity of stream flow, thereby causing the deposition of the sediment load.

Check dams become necessary, where the channel gradients are steep and there is a heavy inflow of sediment from the watershed. They are constructed of local material like earth, rock, timber, etc. These are suitable for small catchment varying in size from 40 to 400 hectares. It is necessary to provide small check dams on the subsidiary streams flowing into the main streams besides the check dams in the main stream. Proper consideration should be given to the number and location of check dams required. It is preferable to minimize the height of the check dams. If the stream has, a very-steep slope, it is desirable to start with a

smaller height for the check dams than may ultimately be necessary.

4.3.3.1 Check dams may generally cost more per unit of storage than the reservoirs they protect. Therefore, it may not always be possible to adopt them as a primary method of sediment control in new reservoirs. However, feasibility of providing check dams at a later date should not be overlooked while planning the construction of a new reservoir.

4.3.4 *Contour Bunding and Trenching*

These are important methods of controlling soil erosion on the hills and sloping lands, where gradients of cultivated fields or terraces are flatter, say up to 10 percent. By these methods the hill side is split up into small compartments on which the rain is retained and surface run-off is modified with prevention of soil erosion. In addition to contour bunding, side trenching is also provided as per requirement.

4.3.5 *Gully Plugging*

This is done by small rock fill dams. These dams will be effective in filling up the gullies with sediment coming from the upstream of the catchment and also prevent further widening of the gully.

4.3.6 *Bank Protection*

This is achieved by terracing, revetment, retaining walls, gabions and spurs.

4.3.7 *By-Pass Canals, Tunnels and Conduits*

The various methods in this category require the construction of some type of diversion dam or weir at the head of the reservoir basin, and a canal, tunnel or conduit leading around the reservoir to a point below the dam where the flow may re-enter the main channels. In such cases the flood flows of sediment laden water are by-passed to the downstream of the dam. In some cases where topography permits construction of new off channel reservoirs can be considered. These reservoirs will invariably have a forebay and check dam on the upstream for trapping the sediment. The stored water in the forebay is led to the reservoir and the sediment trapped is flushed through by by-pass channel/ conduit/tunnel to the main channel downstream of the dam.

4.4 Control of Sediment Deposition

The deposition of sediment in a reservoir may be controlled to a certain extent by designing and operating gates or other outlets in the dam in such a manner as to permit selective withdrawals of water having a higher than average sediment content. The suspended sediment content of the water in reservoirs is higher during and just after flood flow. Thus, more the water wasted at such times, the smaller will be the percentage of the total sediment load to settle into permanent deposits. There are generally two methods: (a) density currents, and (b) waste-water release, for controlling the deposition and both will necessarily result in loss of water.

4.4.1 *Density Current*

Water at various levels of a reservoir often contains radically different concentrations of suspended sediment particularly during and after flood flows. If all wastewater could be withdrawn at those levels where the concentration is highest, a significant amount of sediment might be removed from the reservoir. Because a submerged outlet draws water towards it from all directions, the vertical dimension of the opening should be small with respect to the thickness of the layer and the rate of withdrawal also should be low. With a view to passing the density current by sluices that might be existing, it is necessary to trace the movement of density currents and observation stations (consisting of permanently anchored rafts from which measurements could be made of temperature and conductivity gradient from the surface of the lake to the bottom, besides collecting water samples at various depths) at least one just above the dam and two or more additional stations in the upstream (one in the inlet and one in the middle) should be located.

4.4.2 *Waste-Water Release*

Controlling the sedimentation by controlling waste-water release is obviously possible only when water can be or should be wasted. This method is applicable only when a reservoir is of such size that a small part of large flood flows will fill it.

In the design of the dam, sediment may be passed through or over it as an effective method of silt control by placing a series of outlets at various elevations. The percentage of total sediment load that might be ejected from the reservoir through proper gate control will differ greatly with different locations. It is probable that as much as 20 percent of the sediment inflow could be passed through many reservoirs by venting through outlets designed and controlled.

4.4.3 *Scouring Sluicing*

This method is somewhat similar to both the control of waste-water release and the draining and flushing methods (*see* **4.4.2** and **4.5.3**).

The distinctions amongst them are the following:

a) The waste-water release method ejects sediment laden flood flows through deep spillway gates or large under-sluices at the rate of discharge that prevents sedimentation.

b) Drainage and flushing method involves the slow release of stored water from the reservoir through small gates or valves making use of normal or low flow to entrain and carry the sediment, and
c) Scouring sluicing depends for its efficiency on either the scouring action exerted by the sudden rush of impounded water under a high head through under-sluices or on the scouring action of high flood discharge coming into the reservoir.

4.4.3.1 Scouring sluicing method can be used in the following:

a) Small power dams that depend to a great extent on pondage but not on storage;
b) Small irrigation reservoirs, where only a small fraction of the total annual flow can be stored;
c) Any reservoir in narrow channels, gorges, etc, where water wastage can be afforded; and
d) When the particular reservoir under treatment is a unit in an interconnected system so that the other reservoirs can supply the water needed.

4.5 Removal of Sediment Deposit

The most practical means of maintaining the storage capacity are those designed to prevent accumulation of permanent deposits as the removal operations are extremely expensive, unless the material removed is usable. Therefore, the redemption of lost storage by removal should be adopted as a last resort. The removal of sediment deposit implies in general, that the deposits are sufficiently compacted or consolidated to act as a solid and, therefore, are unable to flow along with the water. The removal of sediment deposits may be accomplished by a variety of mechanical and hydraulic ~~or~~ methods, such as excavation, dredging, siphoning, draining, flushing, flood sluicing, and sluicing aided by such measures as hydraulic or mechanical agitation or blasting of the sediment. The excavated sediments may be suitably disposed off so that, these do not find the way again in the reservoir.

4.5.1 *Excavation*

The method involves draining most of or all the water in the basin and removing the sediment by hand or power operated shovel, dragline scraper or other mechanical means.

The excavation of silt and clay which constitute most of the material in larger reservoirs is more difficult than the excavation of sand and gravel. Fine-textured sediment cannot be excavated easily from larger reservoirs unless it is relatively fluid or relatively compact.

4.5.2 *Dredging*

This involves the removal of deposits from the bottom of a reservoir and their conveyance to some other point by mechanical or hydraulic means, while water storage is being maintained.

Dredging practices are grouped as:

a) Mechanical dredging by bucket, ladder, etc;
b) Suction dredging with floating pipeline and a pump usually mounted on a barge; and
c) Siphon dredging with a floating pipe extending over the dam or connected to an opening in the dam and usually with a pump on a barge.

NOTES

1 Practicality of the two methods, namely, excavation and dredging, requires to be carefully considered in any particular case.

2 Suitable measures to prevent deposition of the dredged silt in the natural channel where it is discharged need to be adopted.

4.5.3 *Draining and Flushing*

The method involves relatively slow release of all stored water in a reservoir through gates or valves located near bottom of the dam and the maintenance thereafter of open outlets for a shorter or longer period during which normal stream flow cuts into or directed against the sediment deposits. Therefore, this method may be adopted in flood control reservoirs.

4.5.4 *Sluicing with Controlled Water*

This method differs from the flood sluicing in that the controlled water supply permits choosing the time of sluicing more advantageously and that the water may be directed more effectively against the sediment deposits. While the flood sluicing depends either on the occurrence of flood or on being able to release rapidly all of a full or nearly full supply of water in the main reservoir is empty. The advantage of this method is that generally more sediment can be removed per unit of water used than in flood scouring or draining and flushing.

4.5.5 *Sluicing with Hydraulic and Mechanical Agitation*

Methods that stir up break up or move deposits of sediment into a stream current flowing through a drained reservoir basin or into a lake current moving through and out of a full reservoir will tend to make the removal of sediment from the reservoir more complete. Wherever draining, flushing or sluicing appear to be warranted, the additional use of hydraulic means for stirring up the sediment deposits, or sloughing them off, into a stream flowing through the reservoir basin should be considered. It has, however, limited application.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 1986 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the latest issue of 'BIS Catalogue' and 'Standards : Monthly Additions'.

This Indian Standard has been developed from Doc No.: WRD 10 (0595).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.org.in

Regional Offices:		*Telephones*
Central	: Manak Bhavan, 9 Bahadur Shah Zafar Marg NEW DELHI 110002	2323 7617 2323 3841
Eastern	: 1/14 C.I.T. Scheme VII M, V. I. P. Road, Kankurgachi KOLKATA 700054	2337 8499, 2337 8561 2337 8626, 2337 9120
Northern	: Plot No. 4-A, Sector 27-B, Madhya Marg, CHANDIGARH 160019	26 50206 265 0290
Southern	: C.I.T. Campus, IV Cross Road, CHENNAI 600113	2254 1216, 2254 1442 2254 2519, 2254 2315
Western	: Manakalaya, E9 MIDC, Marol, Andheri (East) MUMBAI 400093	2832 9295, 2832 7858 2832 7891, 2832 7892

Branches: AHMEDABAD. BENGALURU. BHOPAL. BHUBANESHWAR. COIMBATORE. DEHRADUN. DURGAPUR. FARIDABAD. GHAZIABAD. GUWAHATI. HYDERABAD. JAIPUR. JAMSHEDPUR. KOCHI. LUCKNOW. NAGPUR. PARWANOO. PATNA. PUNE. RAIPUR. RAJKOT. VISAKHAPATNAM.

Published by BIS, New Delhi